Hierarchies in the Hidden sector and Gravitational rescue of gauge mediation

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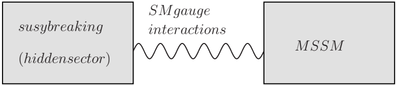
Outline

1. Gauge mediated Supersymmetry Breaking(GMSB) (see lectures by Dedes in Presusy)
2. Gravitational rescue of Gauge mediation
3. Two spurion SUSY scale breaking and model building possibilities
4. An application to GMSB

Features of Gauge Mediation

- GMSB models assume that SUSY is broken in a secluded sector
- Messenger fields communicate susy breaking from hidden sector to MSSM sector



- Messenger fields transform vectorially under SM gauge group

- In mGMSB, soft terms are generated through 1-loop and 2-loop diagrams involving messenger fields coupled to the MSSM fields through gauge interactions. The messengers are connected through the hidden sector which is parameterised by a spurion field X_1 as

$$W_{\text{mess}} = \lambda X_1 \Phi \bar{\Phi}$$

- The soft terms due to gauge mediation at the messenger scale M_1 are given by:

$$\begin{aligned} M'_a &\approx \frac{\alpha_a}{4\pi}\left(\frac{F_1}{M_1}\right) \\ m'^2 &\approx 2\sum_{a=1}^{3}\left(\frac{\alpha_a}{4\pi}\right)^2 C_a \left(\frac{F_1^2}{M_1^2}\right) \\ A' &\approx 0 \end{aligned}$$

- Typically $\Lambda \equiv F_1/M_1$ is chosen to be around 100 TeV to get low energy soft terms around at TeV
- M_1 can have a range between 200 TeV- GUT scale (10^{16}GeV)
- F_1 is scaled accordingly while keeping Λ fixed.
- The low energy spectrum is computed by running the renormalisation group equations

$$\begin{aligned} m^2_{Q_3}(M_{weak}) &\approx 9.4 \times 10^{-5}\Lambda^2 \\ m^2_{U_3}(M_{weak}) &\approx 8.7 \times 10^{-5}\Lambda^2 \\ A_t(M_{weak}) &\approx -0.002\Lambda \end{aligned}$$

- The expressions are evaluated for $M_1 = 10^6$ GeV. Keeping Λ fixed, if M_1 is increased from 10^6 to 10^{14}, then the magnitude of A_t only increases from 0.002Λ to 0.005Λ

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Character of gravitational contribtion in mGMSB

- Can gravity mediation act as additional source?
- Gravity mediation will always contribute to the soft terms at the high scale

$$\begin{aligned} \tilde{m}^2_{ij} &= k_{ij} \int d^2\theta d^2\bar{\theta} \left(\frac{F_1^\dagger F_1}{M_{Pl}^2} \right) \Phi^\dagger \Phi \\ \tilde{M}_{ab} &= f_{ab} \int d^2\theta \left(\frac{F_1}{M_{Pl}} \right) \mathcal{W}^a \mathcal{W}^b \\ \tilde{A}_{ijk} &= \eta_{ijk} \int d^2\theta \left(\frac{F_1}{M_{Pl}} \right) \Phi_i \Phi_j \Phi_k \end{aligned}$$

- For a fixed messenger scale, M_1 (typical value of 10^5 GeV), $F_1 \sim 10^{11}$, so gravitational contributions are negligible

- Owing to the fact that A-terms are zero at the boundary mGMSB is not a viable SUSY breaking model to get 125 GeV Higgs mass
- In single spurion case, Gravitational mediation contributions are negligible

With two hierarchical spurions in the hidden sector: Is it possible to build acceptable model?

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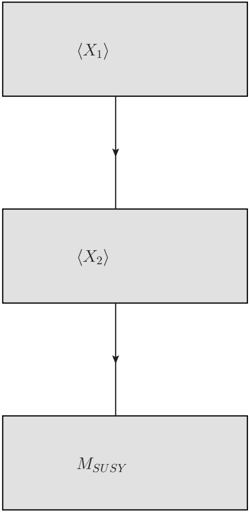
With two hierarchical spurions in the hidden sector: Is it possible to build acceptable model?

- If answer is Yes, what are sources of SUSY breaking?
- Is there a UV complete model which can give rise to SUSY breaking with Hierarchical spurions?

Outline

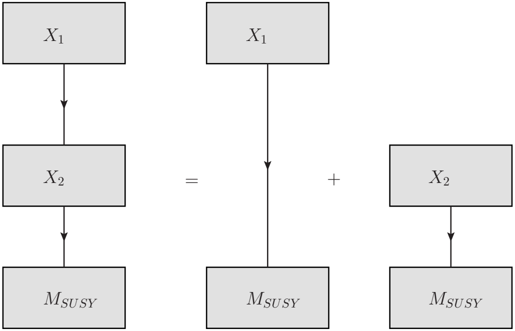
SUSY breaking with two spurions



- Two hidden sector chiral multiplets X_1 and X_2
- M, A, $\tilde{m}$ receive gravity contribution at scale X_1
- Out put at scale X_2 receives extra contributio from gauge mediation (A terms are no longer zero at the boundary)
- Finally, weak scale out put is confronted with experiment.

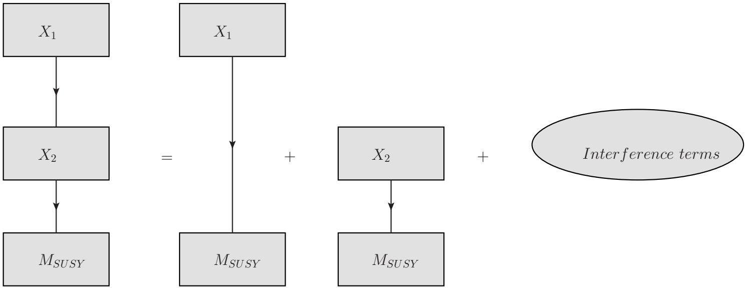
Semi-Analytical expressions for gauginos and A terms

$$M_a(weak) = M_a(weak) + M'_a(weak)$$
$$A_t(weak) = A_t(weak) + A'_t(weak)$$



Semi-Analytical expressions for gauginos and A terms

$$m_{\tilde{f}}^2(weak) \quad = \quad m_{\tilde{f}}^2(weak) + m_{\tilde{f}}^{2'}(weak) + Interference\ \ terms$$



Few comments

- Due to the closed form expressions of two spurion SUSY breaking, finding dependence of low energy spectrum on SUSY breaking, in this case, is more tractable.
- One can embed various SUSY breaking models in this frame work and study the low energy spectrum
- One can also build Hidden sector models which can break SUSY dynamically with two spurions.
- We present an application to GMSB

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Model

- We consider a model of single warped extradimension called Randall-Sundrum models
- The warp factor in this case is chosen to be

$$\epsilon = \frac{M_{IR}}{M_{Pl}} \sim 0.01$$

- We assume the two Higgs doublet H_u and H_d to be localized on the low energy brane (IR brane). Supersymmetry breaking spurion $X = \theta^2 F$ is introduced on the IR brane. SUSY breaking terms are generated by the brane local interactions of the spurion with the bulk fields

The soft breaking terms are of the form:

$$\begin{aligned} m^2_{H_u,H_d} &= \hat{\beta}_{u,d}\ m^2_{3/2} \\ (m^2_{\tilde{f}})_{ij} &= m^2_{3/2}\ \hat{\beta}_{ij}\ e^{(1-c_i-c_j)kR\pi}\xi(c_i)\xi(c_j) \\ A^{u,d}_{ij} &= m_{3/2}A'_{ij}e^{(1-c_i-c'_j)kR\pi}\xi(c_i)\xi(c'_j) \\ m_{1/2} &= k_h m_{3/2} \end{aligned}$$

$\hat{\beta}_{ij}, A', k_h$ are dimensionless $\mathcal{O}(1)$ parameters. $\xi(c_i)$ is defined as

$$\xi(c_i) = \sqrt{\frac{(0.5 - c_i)}{e^{(1-2c_i)\pi kR} - 1}}$$

Table : Soft spectrum for RS set-up $m_{susy} = 1.66$ TeV, $m_{\tilde{g}} = 2.24$ TeV, $tan\beta = 15$

Parameter	Mass(TeV)	Paramater	Mass(TeV)	Paramater	Mass(TeV)
$\tilde{t}_1$	1.26	$\tilde{b}_1$	2.07	$\tilde{\tau}_1$	3.13
$\tilde{t}_2$	2.12	$\tilde{b}_2$	2.20	$\tilde{\tau}_2$	3.412
$\tilde{c}_R$	2.17	$\tilde{s}_R$	2.20	$\tilde{\mu}_R$	0.490
$\tilde{c}_L$	2.31	$\tilde{s}_L$	2.31	$\tilde{\mu}_L$	0.796
$\tilde{u}_R$	2.17	$\tilde{d}_R$	2.20	$\tilde{e}_R$	0.485
$\tilde{u}_L$	2.31	$\tilde{d}_L$	2.31	$\tilde{e}_L$	0.725
m_{A^0}	3.01	$m_H^{\pm}$	3.01	m_h	0.1243

Back up slides